

Difficulties in Evaluating Systolic Murmurs in Children

With Special Reference to the Functional Systolic Murmur

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SUMMARY

As a guide in distinguishing between organic and functional systolic murmurs, five characteristics of a murmur should always be noted, namely, (a) the location of maximal intensity of the murmur; (b) the intensity of the murmur itself; (c) the character of the murmur, that is, whether it is blowing, rumbling, rough or harsh; (d) the transmission of the murmur; and (e) the duration of the murmur and its time within the cardiac cycle.

Functional systolic murmurs may be found at any of the "valve areas," are usually faint to moderately loud, are usually soft and blowing in quality, are usually only slightly transmitted, and are usually not heard immediately following the first heart sound.

In doubtful cases, those in which history and physical examination alone are not sufficient to make a diagnosis of functional systolic murmur, further studies should be undertaken to determine the presence or absence of organic heart disease.

Until a diagnosis of organic heart disease can be made with reasonable certainty, there should be no restriction of activity imposed, because of the likelihood of the development of cardiac neurosis in the patient.

FOR years the problem of the systolic murmur has been one of great interest for those concerned with cardiology and the proper interpretation of cardiac murmurs, and the pendulum has swung from one end of the arc where all systolic murmurs were considered indications of heart disease to the other end where practically none of the systolic murmurs were considered indicative of heart disease. Somewhere between these two points of view lies the real answer. Knowing full well the difficulties that lie in wait for the physician in attempting to interpret the systolic murmur, and knowing also the wide differences of opinion that exist on this question, the author has undertaken to present a few observations which may be of help as a guide to evaluation of the systolic murmur, with particular reference to the "functional" systolic murmur in childhood and adolescence. This is not a statistical survey, but rather a review of the findings as they have been observed in the Children's Cardiac Diagnostic Clinic of the San Francisco Health Department.

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As more and more children of primary and secondary school age have been referred to the clinic, it has been noted that the parents of an impressively large number of patients have been told that the children have a heart murmur, and by inference, cardiac disease. While many of these children have been found to have murmurs of organic origin, there have also been many with systolic murmurs who have been found to have no evidence of organic heart disease after careful study by history, physical examination, fluoroscopy, and electrocardiography. Many of this latter group have had some or considerable restriction in their activities, have had their schooling interrupted, have been made to feel that they are different from other children, and have been a considerable source of worry to their parents. Therefore there is good reason for presenting a review of the findings which may assist the practicing physician in evaluating these functional murmurs, thus aiding in protecting both the child and his family from needless invalidism, both physical and mental.

"It is of great importance to recognize and remember that most systolic murmurs do not indicate the presence of any organic heart disease. Nevertheless, serious diagnoses and bad prognoses have frequently been made largely on the basis of such murmurs. On the other hand it should be recognized that even slight systolic murmurs, except in the pulmonary valve area, are not normal: they demand study as to their cause. Often they are found to be unimportant 'functional' murmurs, but frequently they are evidence of the presence of some important or serious disease acting on the circulatory apparatus, even though there be no heart disease itself." (Paul D. White)⁴

This presentation is concerned with those murmurs which fall into the category of the functional murmur. Where facilities are not available for complete study, the physician must rely in large part on the history and the physical findings, chiefly auscultation; but this does not mean that further studies should not be carried out, elsewhere if necessary, should there be any doubt as to whether a murmur is functional or not. Indeed, to rely entirely on auscultation would be to lose sight of medical goals, but at least a physician should be able to form an opinion as to the type of systolic murmur present. Further studies can then be carried out if they seem indicated.

Auscultation depends on the auditory acuity of the observer and on his experience. Experience in auscultation is a most important factor in attempting to decide whether a murmur is functional or not. Before any pathological process can be recognized, the range of the sounds of the normal heart should

be well understood, and therefore it is well to seek as much information as possible from all patients one may see. By careful auscultation of the heart, even though there is no clinical evidence suggesting cardiac disease, one may listen to many normal hearts and learn the range of the normal sounds. This procedure is of inestimable value if one is to familiarize himself with the pitch, intensity, quality, and location of heart sounds and murmurs, as well as to school himself to recognize the third heart sound, which is often confused with a murmur and yet is a normal auscultatory finding in many cases.

In evaluating any murmur, it necessary to enumerate several characteristics. First, after noting whether the murmur is systolic or diastolic in time, the location of the maximal intensity of the murmur must be noted, that is, in which of the several "valve areas" the murmur is best heard. The loudness of the murmur itself should then be noted, that is, whether it is very faint or very loud or of some intervening intensity. Levine³ has graded murmurs according to their intensity from grade one through grade six, the latter being the loudest. This is a convenient method of deciding the intensity of the murmur but the interpretation varies with each individual examiner, depending on his experience. Just as convenient, and a method which for many examiners is easier, is to describe a murmur as to whether it is very faint, moderately faint, moderately loud, or very loud; but whichever method is used, it should be used consistently, so that one may always compare the intensity of murmurs at different times in the same patient. This gradation is very important in deciding whether one will consider a murmur functional or not. Almost all functional murmurs are faint murmurs.

The quality of the murmur is of great importance. It should be classified as blowing, rumbling, rough, or harsh. Functional murmurs are blowing in character, as well as being faint.

The transmission of the murmur is also of importance. Transmission is determined by the loudness of the murmur together with the nearness of the heart to the stethoscope. In general any murmur which is transmitted fairly widely is a loud murmur; functional murmurs are not loud, and therefore are not transmitted as a general rule, at least not over a wide area.

The time during systole that the murmur is heard, and its duration, should be noted. Functional murmurs seldom begin with or immediately follow the first sound; there is almost always a short gap between the end of the first sound and the beginning of the faint blowing functional systolic murmur. This has been pointed out by Evans¹ in his phonocardiographic studies of heart murmurs.

With these particular characteristics in mind, one may evaluate with more accuracy the auscultatory findings in an attempt to differentiate functional from organic murmurs. Again it should be emphasized that auscultatory findings alone cannot always give the final answer as to whether a murmur is

functional or not, but certain characteristics are helpful in guiding the physician to some conclusion.

The functional murmur at the mitral, or apical, area is in general located at the cardiac apex, or just medial to the apex. The murmur ranges in intensity from barely audible to faint or moderately faint, but it is never a loud murmur. It is not harsh or rough, but has a blowing quality, which may also be described as a whiff, should the murmur be very faint. It is heard in mid-systole or toward the end of systole. If there is no appreciable gap between the first sound at the apex and the beginning of the murmur, even if the murmur is quite faint, suspicion should be aroused that the murmur is organic, and further studies should be made to rule out this possibility. In the presence of tachycardia, it may be very difficult to determine the presence or absence of this small gap, but every effort should be made to detect such a gap. Some murmurs in the mitral area are present only in the last half of the systole, and if they are faint, non-radiating, and blowing, they are most likely functional in origin.

The changes in the auscultatory findings which can be brought about by changes in respiration are of considerable value, but not, of course, pathognomonic of a functional murmur in the mitral area. Functional systolic murmurs, unlike organic systolic murmurs, frequently can be made to disappear by complete deep inspiration. This is not always true but in many cases can be demonstrated. If the murmur does not completely disappear, it usually becomes faint enough so that it can then be classed as a very faint blowing murmur. As the patient is allowed to breathe normally again, the murmur will reappear, or will become louder than it was during deep inspiration. However, it never becomes a truly loud murmur, but will regain the intensity of sound which originally suggested the presence of a functional murmur. Frequently during the diminution or disappearance of the sound, the pulse rate will become considerably slower. This is a normal phenomenon, particularly in young children. One other feature which can be found frequently in functional systolic murmurs during deep inspiration is that the murmur does not reach its full intensity, even though softer than during normal respiration, until after two or three beats have been heard. This is particularly true if auscultation is carried out while the breath is being held in deep inspiration. Organic systolic murmurs may also become less pronounced during deep inspiration, but they do not disappear completely. The loud, and particularly the rough components of the sound still remain, although somewhat diminished.

Change in position of the patient, that is, assumption of the upright or recumbent position, also influences functional systolic murmurs more than organic systolic murmurs. Without having the patient consciously change his respiration, and with the stethoscope held in approximately the same position on the chest, it has been found that functional systolic murmurs are slightly louder in the recumbent position than in the upright position. Usually the oppo-

site is true with organic systolic murmurs. This variation should always be looked for in any cardiac examination. It has been found that on numerous occasions organic heart disease has been missed simply because the examiner did not examine the patient in the recumbent as well as in the upright position. It is well to note in passing that occasionally mid-diastolic murmurs and frequently presystolic murmurs at the apex have been overlooked because auscultation was not carried out with the patient in the left lateral position as well as in the two other positions mentioned.

Transmission of the functional systolic apical murmur is almost always minimal. This is of considerable help, since in contradistinction, organic systolic apical murmurs are almost always transmitted toward or into the axilla, or the back, or both. They are rarely if ever transmitted upward. If there is any transmission present in a suspected apical functional systolic murmur, the patient should be examined in both the recumbent and upright positions with special reference to the transmission of the murmur. It has been found, more often than not, that in the upright position the transmission, if any, of the functional systolic murmur tends to be toward the axilla, while in the recumbent position, the radiation will shift so that the murmur, becoming slightly more intense in the recumbent position, will also tend slightly to radiate upward toward the left of the sternum, rather than to the axilla. There will usually be no transmission to the back in either the upright or the recumbent position.

A functional systolic murmur to the left of the sternum is usually less perplexing than that found at the apex. It may be somewhat louder than that found at the apex, but it is never harsh or rasping in quality. It is blowing in quality, and extends from the third to the fifth interspace, being maximal in the fourth interspace. The murmur is slightly higher pitched than that in the mitral area. Unlike the murmur in the mitral valve area, it is often difficult or impossible to decide whether this murmur begins with or immediately after the first sound, but if it can be heard after the first sound with a gap between the onset of the murmur and the end of the first sound, there is a good likelihood that it is a functional murmur. Phonocardiographic studies² have demonstrated, however, that the functional murmur begins after the first sound.

Usually, deep inspiration does not abolish this type of functional systolic murmur, probably because the sound originates close to the chest wall, but some faint systolic murmurs in this area will disappear completely with deep inspiration. Position of the patient has less influence on the intensity of this murmur than on the functional systolic murmur at the apical area, but here again it can often be determined that the murmur will become somewhat more intense in the recumbent position.

As has already been noted, this functional systolic murmur has a wider area of transmission than that of the apical area, and may at times even radiate to the lower end of the sternum; but it still remains a

faint blowing type of murmur, with its maximal intensity at or very near the fourth left interspace. This should be readily heard on careful auscultation. The murmur of interventricular septal defect which is heard in the same area is differentiated by its loudness, by its rough or harsh quality, and by the presence of a palpable thrill in most cases. In passing, it may be stated that the murmur of interauricular septal defect, when it is present, is also heard in this area. Like the functional systolic murmur, it is usually soft and blowing in quality and may be indistinguishable from a functional systolic murmur. It is mentioned here chiefly because of the fact that the lesion is frequently overlooked, and, if thought of during a cardiac examination, will be more readily found. Further studies including fluoroscopic and electrocardiographic examinations are necessary to establish this diagnosis.

A functional systolic murmur in the aortic area, that is, in the right second interspace, is again soft and blowing in quality, and varies in intensity from faint to moderately loud. It is never harsh or rough in quality. It may occupy the whole of systole or any part of it, but is usually considerably less pronounced at the end of systole. It is little influenced by changes in the phase of respiration; to a lesser degree than the functional systolic murmur to the left of the sternum, it may be intensified in the recumbent position. Aortic functional systolic murmurs may radiate to the apical area. However, the higher pitch of the murmur will help to distinguish it from the functional systolic murmur of the apex, and in most cases it can be traced from the aortic area to the apex, with its maximal intensity located in the aortic area. Pulmonary functional systolic murmurs may also radiate to the aortic area, and be considered aortic murmurs, but careful attention to the area of maximal intensity of the two murmurs should distinguish them. Attention should be paid to the intensity of the aortic second sound; it may frequently be less intense than the first sound, but it is never decidedly diminished or absent as is so frequently the case with the murmur of aortic stenosis. There probably is, at some point in the course of the development of the murmur of aortic stenosis, a time when the systolic murmur associated with this disease is indistinguishable from that of a moderately loud early functional murmur, and in that case one could not be sure of the differentiation. But as the patient is observed and his progress is followed, the presence of an increasingly loud systolic murmur, together with the development of a decidedly diminished second sound and a palpable systolic thrill, will then permit the correct diagnosis. Hypertension, while not common in children, will produce a blowing systolic murmur in this area, the aortic second sound will be loud and eventually ringing, and the murmur will be chiefly in the latter portion of systole. Elevation of the blood pressure will be evident.

Pulmonary systolic murmurs are the commonest of all murmurs.⁴ Pulmonary functional systolic murmurs are often moderately loud, but are blowing in

quality. The pitch of the murmur is somewhat higher than that at the apical area, is very like that of the functional systolic murmur in the aortic area, and is often indistinguishable from the latter except in the location of its maximal intensity. The murmur is not rough or harsh in quality. It can be brought out more easily than any of the functional systolic murmurs in other areas by having the patient in the recumbent position, and can often be greatly intensified by having the patient in full expiration. In this latter case, the murmur may become surprisingly loud but still retain its blowing character. Deep inspiration, on the other hand, frequently causes complete abolition of the murmur. The pulmonary functional systolic murmur may radiate down the left border of the sternum or into the aortic area, but again careful auscultation should reveal the site of maximal intensity of the murmur. As a general rule, however, the pulmonary functional systolic murmur is fairly well circumscribed. In association with this murmur, there is frequently found a reduplication of the second sound in the pulmonic valve area, although this is not present in every case. Exercise will frequently accentuate a functional pulmonic systolic murmur; the murmur becomes less pronounced as the heart action becomes less forceful during the ensuing rest period.

Pulmonary hypertension may produce a systolic murmur in the pulmonary area which may simulate a functional murmur, the murmur being blowing in character and occupying all or part of systole. In this condition, the pulmonary second sound will be considerably louder than normal, and will usually be snapping with more pronounced reduplication than is usually found. Other changes in the heart will be found, and should be looked for when the abnormalities just mentioned are noted. Coarctation of the aorta may also produce a systolic murmur at the pulmonary area indistinguishable from the moderately loud pulmonary functional murmur, but other signs of coarctation will be found if searched for. Patent ductus may likewise produce a murmur similar to a functional systolic pulmonic murmur, but the murmur is louder than the functional murmur; there will also be an associated diastolic murmur heard in the same area, usually long and pronounced, without which a diagnosis of patent ductus should not be entertained, except possibly in very young children or infants. A palpable systolic thrill is almost always present in this condition.

In conclusion, it may be said that one of the greatest difficulties associated with systolic murmurs, especially in children, is the determination as to whether any given murmur is functional or organic. There are many differences of opinion regarding the interpretation of auscultatory findings of systolic murmurs in children. Those experienced in pediatric cardiology realize that infinite care is needed in the proper evaluation of such murmurs. Experience is an invaluable aid in deciding these problems.

In the author's experience at the Children's Cardiac Diagnostic Clinic, many children have been referred because of a systolic murmur which seemed

to the author to be obviously functional; and on further studies, including a careful history, physical examination, fluoroscopy and electrocardiography, such proved to be the case. In such cases there was found to be no limitation of cardiac reserve, no enlargement of the heart, no abnormality of cardiac outline on fluoroscopy, and no deviations from the normal range in the electrocardiogram. In this group it seemed apparent that too little attention had been paid to the facts that could have been obtained clinically without extensive laboratory procedures. Fluoroscopy, blood studies, and electrocardiography were not necessary in this group of patients, although these examinations were carried out in the clinic for further proof that the murmur was functional. In this group of cases, the history and physical findings would have been sufficient to warrant a diagnosis of a functional systolic murmur, and much psychic trauma and expense to the patient and his family could have been avoided.

Another group of patients was seen in which it was suspected that the systolic murmur heard was functional in nature, but this could not be determined until further studies were carried out. In such circumstances, completion of studies to determine whether a systolic murmur is functional or not, is recommended. It is with regard to such murmurs that there is the greatest difference of opinion among experienced cardiologists. In cases in which doubt exists, auscultatory findings alone should not be relied upon. Even if results of all studies are negative, the patient should be carefully followed at frequent intervals for a period of years, since it is only by this means that the true nature of the murmur can be established. But if there is no evidence of cardiac disease after careful follow-up examinations, the patient should be told that such is the case, and no restriction should be imposed solely because of the presence of a murmur. Nor should restriction be imposed during the period of observation, since evidence of heart disease has not been established, and cardiac neurosis with its resultant loss of normal development of the child can easily be created. Most physicians probably have seen patients who have been confined to bed for a prolonged period of time because of the presence of a heart murmur, although the murmur was not organic but functional in origin. Such tragedies for patients and their families should be eliminated if physicians become more alert to the characteristics of a functional murmur, and make every effort, particularly in doubtful cases, to determine the actual presence or absence of cardiac disease, using careful history taking and physical examination as the starting point from which to proceed to further diagnostic tests as they appear necessary.

1. Evans, W.: Heart murmurs, Part I, *British Heart Journal*, 9:1-15 (June), 1947.
2. Evans, W.: Heart murmurs, Part II, *British Heart Journal*, 9:225-240 (Oct.), 1947.
3. Levine, S. A.: *Clinical Heart Disease*, 3rd Ed., W. B. Saunders Co., 1945.
4. White, P. D.: *Heart Disease*, Macmillan Co., 1937.